world onto an image plane, a two-dimensional space. Rectification is the process of reprojecting from the image plane onto another plane, which is not necessarily parallel to the image plane. When rectifying the image onto an ordinary perspective plane, the rectification can be accomplished without knowledge of the three-dimensional locations of the points of the

5   underlying three-dimensional world.

[67]   In block 23, an edge operation is applied to the rectified image from block 22 to obtain an edge image. The edge operation determines edges of features in the rectified image, and the edge image can be regarded as a line-based rendering of the rectified image. Examples of an edge operation include Sobel and other gradient operators.

10   [68]   In block 24, the edge image from block 23 is edited to obtain a modified image. The image can be edited in a number of ways as discussed further below with respect to Figure 4. The image can be edited, for example, by using Adobe PhotoShop. By editing the edge image of a camera-motion layer, the entire video sequence relying on the camera-motion layer is modified. With the invention, only the camera-motion layer is edited, and the corresponding

15   sequence of frames in the composite modified video sequence is affected. This is a powerful advantage over the conventional techniques, which require every frame of the video sequence to be edited.

[69]   In block 25, the modified image is rectified from the ordinary perspective plane to the original image plane.

20   [70]   In block 26, the modified image rectified in block 25 is converted to obtain a modified camera-motion layer. The conversion in block 26 is the reciprocal of the conversion in block 21.

37112-174878

[71]   Figure 4 illustrates various aspects of editing a camera-motion layer in block 13

of Figure 2 and in block 24 of Figure 3. Figure 4 illustrates various editing possibilities with the

invention. One or more camera-motion layers can be edited using one or more of the

possibilities illustrated in Figure 4. The possibilities in Figure 4 are generally described as being

5   applicable to camera-motion layers because they are applicable to editing both original camera-

motion layers and modified camera-motion layers. As discussed above, a single change to one

camera-motion layer affects the entire video sequence of multiple frames relying on the camera-

motion layer, and the single change does not need to be made laboriously to each frame of the

original video sequence.

10   [72]   If a modification discussed herein is saved as an additional camera-motion layer,

leaving the original camera-motion layer untouched, the additional camera-motion layer can

have various effects parameters associated with it, such as an on/off time, a level of opaqueness,

and/or a fade-in/fade-out parameter.

[73]   The editing possibilities depicted in Figure 4 can be accomplished using

15   conventional software. For example, images can be edited using Photoshop by Adobe Systems

Incorporated of San Jose, California. As another example, video can be edited using Premiere by

Adobe Systems Incorporated of San Jose, California. As a further example, three-dimensional

animation can be performed using 3D Studio MAX by Discreet of Montreal, Quebec, Canada.

[74]   In block 31, an object is inserted in a camera-motion layer. The edges of the

20   inserted object are preferably blended so that it is difficult to determine that the object is an

artificial insertion. As an example, a machine for dispensing canned soda can be inserted into a

video scene of a hotel lobby. In addition, the carpet next to the soda machine can be changed to

account for the fluorescent light from the soda machine. Further, using on/off times, the soda

37112-174878

machine can be seen to appear and then disappear from the hotel lobby during the composite modified video sequence.

[75] In block 32, an object is deleted from a camera-motion layer. One or more portions of the static background of the camera-motion can be removed (e.g., "airbrushed out") such that it is difficult to determine the portion of the background that has been modified. As an example, a door can be deleted from the wall in a video scene of a hotel lobby. In place of the door, the pattern of the wall can be repeated.

[76] In block 33, an object is changed in a camera-motion layer. Changing an object includes aspects of inserting an object and deleting an object to make a change to the camera-motion layer. As an example, a potted plant in a video scene of a hotel lobby can be moved from one location to another. Further, using fade-in/fade-out parameters, the potted plant can appear in the composite modified video sequence to vanish slowly from one location and to reappear slowly in another location.

[77] In block 34, the camera-motion layer is entirely replaced with another camera-motion layer. The replacing camera-motion layer can be obtained from a video sequence or can be an image. Examples of such an image include: a computer-generated image; a computer-aided drawing; a digital photograph; a scanned image; and a frame from a video sequence. As an example, the guests checking into one hotel lobby in the original video sequence can be viewed in the composite modified video sequence to be checking into an entirely different hotel lobby or into a cartoon hotel lobby.

[78] In block 35, a video sequence is added to a camera-motion layer. A video window is inserted in the camera-motion layer that maintains the motion characteristics of the camera via the camera motion parameters of the decomposed original video sequence. This is an

37112-174878